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Title: Association between sleep quality and executive functions in a sample of first-semester medical students at a public university.

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Introduction

Sleep is a physiological state that consists of sequential and cyclic phases, during each stage vital processes occur in order to maintain homeostasis.
In recent decades the prevalence of sleep disorders has increased worldwide.

Sleep quality involves quantitative and qualitative aspects such:

- Duration.
- Onset latency.
- Efficiency to achieve rest and restorative effect.
- Daytime dysfunction.
- Sleep disturbances.

(D'Ambrosio, 2019; Krystal & Edinger, 2008).

Sleep quality in university students

- The sleep insufficiency is usual among university students, they tend to reduce the time spent sleeping in order to achieve their academic goals; particularly in medicine career.
- In the first-year students are more vulnerable, because the changes that the transition to university implies.
- In medical students poor sleep quality impairs cognitive functions that could affect their academic performance.

Executive Functions and sleep

Sleep quality could influence the cognitive skills that enable students to develop their academic skills, such as executive brain function that underlie academic performance.

Such functions are cognitive abilities that allow transforming thoughts and emotions into actions, it include four domains:

- Attentional control,
- Information processing,
- Goal setting,
- Memory cognitive flexibility.

➢ Executive functions are essential to learning and to plan and achieve objectives of students.

(Jiménez, Broche, Aimée & Díaz, 2019;Anderson, 2002; Lezak et al., 2004)

Methodology

Study Design and Participants

Study design

- Study was quantitative, descriptive, correlational, cross-sectional, non-experimental.
- Study was conducted during the period from August to December 2021

Population

- Population was taken as first semester students of the midwife surgeon medical career (MCP) of the public University in the South of Jalisco, Mexico.
- The sample was calculated with a 95% confidence interval (CI), expected error of 5%, n=38, the sampling was probabilistic by clusters.

Inclusion criteria:

- Be a first semester MCP student and be agreed to participate
- Sociodemographic variables measured were: sex, age, whether they live with their parents or not, with whom they share a room, whether they work or not.
- Variable independent: sleep quality
- Dependent variable: executive functions

Instruments

Pittsburgh Sleep Quality Index (PSQI).

Consists of 19 items grouped into 7 sleep components: quality, latency, duration, efficiency, disturbances, use of sleep medication and daytime dysfunction.

Scoring.

Each component is scored from 0 to 3. The sum of the 7 components gives the total score in a ranges from 0 to 21 points, the higher score means the worse quality of sleep. (0.83 Cronbach's alpha).

WisConPC test

The test consists of the presentation of four sample cards (pattern cards), together with a block of 128 stimulus (response) cards. The application time is 15 to 20 minutes.

The test show: total number of stimuli (response cards) presented, total and percentage of correct and incorrect responses, total perseverations, completed sequences, total average reaction time (RT), average RT of correct responses and average RT of incorrect responses.

Assessed domains.

Evaluates executive functions in 4 domains: attentional control, information processing, cognitive flexibility, and goal setting.

Methodology

Sociodemographic status	Stage Pre	Stage Post
Online survey with 19 items was applied through Google Forms platform, the survey began with informed consent.	Two weeks after the beginning of the semester, with the objective that the students had a period of adaptation to the entrance to the university in its virtual modality.	15 days before the end of the semester, to avoid acquiescence due to the workload and final exams.

Statistical Analysis

- The statistical analysis was correlational between quantitative variables, descriptive and dispersion data are reported, a normality test was performed to verify the distribution of the data. The Wilcoxon test was performed, this was applied for both tests.
- To determine the strength of correlation between variables, Spearman's correlation coefficient test was used.
- The statistical tool Statistical Package for the Social Sciences v. 25.0 (SPSS).

Results

Sociodemographic Information

63% of the participants were female and 37% male.

73% lived with their parents.

71% did not work.

Table 1. Sociodemographic data

Variable	Frequency
Age	18.21 (DE = .41)
Sex	
Women	n = 24 (63%)
Men	n = 14 (37%)
Studying	
Medical student	n = 38 (100%)
With whom do you currently live?	
Nuclear family (parents and siblings)	n = 28 (73%)
Others	n = 10 (27%)
With whom do you currently share a room?	
Friend/Partner	n = 3 (8%)
Family	n = 10 (27%)
I do not share	n = 25 (65%)
Are you currently working?	
weekends	n = 9 (24%)
Half time	n = 2 (5%)
I do not work	n = 27 (71%)

- At the beginning of the semester 60% had good sleep quality, at the end 47% had good sleep quality.
- Sleep latency and sleep efficiency at the beginning of the semester as good and fairly good.
- Students reported sleeping between 6 and 7 hours.

Table 2. Sleep quality of medical students at the beginning and end of the semester.

		Beginning of semester		End of semester	
Component	**Scale**	**N**	**%**	**N**	**%**
Sleep quality	Very good	7	18%	0	0%
	Fairly good	16	42%	18	47%
	Fairly bad	0	0%	12	32%
	Very bad	14	37%	7	18%
Latency	Very good	14	37%	16	42%
	Fairly good	11	29%	12	32%
	Fairly bad	11	29%	3	8%
	Very bad	1	3%	0	0%
Sleep duration	> 7 hours	6	16%	0	0%
	6-7 hours	14	37%	6	16%
	5-6 hours	18	47%	10	26%
	< 5 hours	0	0%	22	58%

- At the beginning of semester sleep efficiency was 69% while at the end of the semester was 34%.
- Sleep disturbance was less than twice a week in 79% of the students as long as at the end of semester was 58%.
- 34% use sleep medication at the beginning of semester while at the end was 44%.

		Beginning of semester		End of semester	
Component	**Scale**	**N**	**%**	**N**	**%**
Sleep efficiency	>85%	14	37%	0	0%
	75-84%	12	32%	13	34%
	65-74%	6	16%	0	0%
	< 65%	6	16%	25	66%
Sleep disturbance	Not during past month	5	13%	14	37%
	Less than once a week	23	61%	13	34%
	Once or twice a week	7	18%	9	24%
	Three or more times a week	2	5%	2	5%
Use of sleep medication	Not during past month	25	66%	21	55%
	Less than once a week	13	34%	12	32%
	Once or twice a week	0	0%	5	13%
	Three or more times a week	0	0%	0	0%

- At the beginning of semester 92% of the students had daytime dysfunction, at the end of semester 97% had dysfunction.
- 78.94% of the students are bad sleepers at the beginning of semester while at the end 100% of the studens was bad sleepers.
- The average sleeping hour per day at the beginning of semestre was 6.05 hours, at the end was 2.42 hours.

		Beginning of semester		End of semester	
Component	**Scale**	**N**	**%**	**N**	**%**
Daytime dysfunction	Not during past month	3	8%	1	3%
	Less than once a week	12	32%	6	16%
	Once or twice a week	11	29%	20	53%
	Three or more times a week	12	32%	11	29%
Global PSQI score	Good sleepers	8	21.05%	0	0%
	Bad sleepers	30	78.94%	38	100%
Average sleeping hours per day at the beginning of semester		6.05			
Average sleeping hours per day at the end of semester		2.42			

Comparisons of sleep quality between the beginning and end of semester period in medical students (Table 3).

- There are statistically significant changes between pre-assessment and post-assessment. At the beginning of the semester the duration component scores were 1.32±0.73, while at the end of the semester they were 2.42±0.75.
- The efficiency component scores were 1.11±1.08 and 2.32±0.96 respectively. The increased scores indicate that sleep duration and efficiency was poor at the end of the semester.
- The total PSQI score showed statistically significant changes in the score at the beginning of the semester 8.31±3.41 compared to that at the end of the semester 10.92±1.81, comparisons are shown in the total score, the score increased between the pre evaluation and post evaluation, which translates into sleep problems.

Table 3. Wilcoxon t-test to compare the score of the 7 components of the Pittsburg sleep quality index.

Component	Beginning of semester	End of semester	P
Sleep quality	1.55 (1.17)	1.71 (.76)	.56
Sleep Latency	1 (.90)	.84 (.82)	.36
Sleep duración	1.32 (.73)	2.42 (.75)	.001
Sleep efficiency	1.11 (1.08)	2.32 (.96)	.001
Sleep disturbance	1.16 (.71)	.97 (.94)	.301
Use of sleep medication	.34 (.48)	.58 (.72)	.060
Daytime dysfunction	1.84 (.97)	2.08 (.74)	.231
Global PSQI score	8.31 (3.41)	10.92 (1.81)	.001

Notes: X: media; SD: Standard deviation

- The results of the WisconPC test showed no significant changes between the initial and final application.
- Significant difference was found in the variable of average time of correct answers, indicating that students took less time to answer correctly in the test applied at the end of the semester.

Table 4. Wilcoxon test to compare the score of the WisconsinPC test.

Component	• Beginning of semester	End of semester	p
Total number of correct responses	48.89 (7.10)	50 (6.53)	.631
Average hit time	2.41 (1.26)	1.83 (.44)	.042
Total numbers of errors	2.40 (.86)	2.21 (.81)	.261
Average per response (seconds)	2.30 (.95)	1.97 (.60)	.115
Total of perseverations	7.26 (4.64)	5.94 (3.02)	.216

- The correlation between the components of the Wisconsin test showed that the greater the average reaction time per response, the greater the average reaction time for successes (r=.86, p<.01).
- The greater the average reaction time for errors, the greater the average reaction time for successes (r=.68, 05p<.).
- The greater the total average reaction time, the greater the average reaction time for errors (r=.56, p<.01).

Graphic 1. Spearman correlation between the components of the Pittsburg sleep quality index and the Wisconsin components.

	C	L	D	E	A	UDM	DD	NDA	TPA	TPE	PPR	TP
C	1											
L	.05	1										
D	.40*	-.02	1									
E	-.20	-.07	- 33*	1								
A	-.01	.42*	.01	-.39	1							
UDM	-.27	-.06	.08	.11	-.18	1						
DD	.08	.02	.08	-.37	-.03	-.18	1					
NDA	.17	-.14	-.10	-.13	-.09	.21	.02	1				
TPA	.02	-.07	.26	.06	.140	-.03	-.06	-.30	1			
TPE	.02	.01	.31	.09	.13	.22	-.20	-.20	.68*	1		
TPR	-.07	.14	.19	.14	.01	-.05	-.09	-.35*	.86**	.56**	1	
TP	.07	.13	-.07	-.16	.25	-.17	-.12	-.27	-.09	-.27	.80	1

Note: Quality (C), Latency (L), Duration (D), Efficiency (E), Alterations (A), Use of sleep medication (UDM), Daytime dysfunction (DD), Number of hits (NDA), Average reaction time of hits (TPA), Average reaction time of errors (TPE), Average reaction time per response. (TPR), Total perseverations (TP). ***p<.001, ** p<.01, *p<.05.

Conclusions

The academic load in first semester medical students reduces the time allocated to sleep and reduces the efficiency and duration of sleep resulting in students with sleep problems or "bad sleepers"; however, sleep problems have no association with executive functions and therefore no impact on the academic performance of first semester medical students.

The results presented highlight the need to explore other cognitive, behavioral and psychological variables that could influence sleep quality and cognitive functions related to overall academic performance, with the aim of developing a multivariate model that allows designing intervention programs that promote the well-being of the student community.

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Acknowledgements

Methodology

Study Design and Participants

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The study was conducted during the period from August to December 2021, the population was taken as first semester students of the midwife surgeon medical career (MCP) of the public University in the South of Jalisco, Mexico.

The sample was calculated with a 95% confidence interval (CI), expected error of 5%, n=38, the sampling was probabilistic by clusters,

Inclusion criteria:

Be a first semester MCP student

Be agreed to participate,

sociodemographic variables measured were: sex, age, whether they live with their parents or not, with whom they share a room, whether they work or not. The study variables considered were sleep quality as an independent variable and executive functions as a dependent variable.

The procedure was developed in two stages, one >pre<, two weeks after the beginning of the semester, with the objective that the students had a period of adaptation to the entrance to the university in its virtual modality; and an application in a >post< stage, 15 days before the end of the semester, to avoid acquiescence due to the workload and final exams.

An online survey with 19 items was applied to collect information on the sociodemographic status of the students. The link to access the Google Forms platform where the survey was located was shared with the students by email, and the survey began with informed consent, in case the student did not wish to participate, the form thanked him/her and did not require more information. In case the student decided to participate, the form displayed the sociodemographic survey and the Pittsburgh test for them to answer. The results were added to an individual folder with the student's name on the Google Drive platform, which only the participant and the researchers could access (data protection). At the end of the study, participants were able to review the results of the tests that were applied to them in the research, which allowed them to know their quality of sleep and their performance in executive functions**.**

Ethical Considerations

The present research work is based on the Regulations of the General Health Law on research, taking as a basis the following articles: article 16 to protect the privacy of the individual, article 17 was considered a research with risk minimum because it answered psychological tests, article 57 was also considered where the informed consent was influenced by some authority, in this case the present study was authorized by the Ethics Committee of the University Center, with folio CEI/045/2021. The application of the principles of the Declaration of Helsinki (beneficence, respect for human dignity and justice) of the World Medical Association for Medical Research Involving Human Subjects was considered for the development of the study.

Correlation between Sleep Quality Index scores and Wisconsin test results.

Correlation was performed between the total score of the PSQI, executive functions and hours of sleep, another one between all the components of the PSQI and the components of the Wisconsin test. Correlations were performed using Spearman's test, from which it was determined that there is no correlation between the variables of the total score of the PSQI and executive functions, in addition to hours of sleep and executive functions.

Graphic 1 shows the correlation between the PSQI components and the Wisconsin test components (lower left gray box), correlation between the PSQI components (upper green triangle) and correlation between the Wisconsin test components (lower orange triangle).

The correlation between the components of the Wisconsin test showed that the greater the average reaction time per response, the greater the average reaction time for successes ($r=.86$, $p<.01$), and the greater the average reaction time for errors, the greater the average reaction time for successes ($r=.68$, 05p<.). Finally, we observed that the greater the total average reaction time, the greater the average reaction time for errors ($r=.56$, $p<.01$).

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